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ABSTRACT

This paper presents a model for obtaining and organizing managment information for decision making in university planning, developed by the Bureau for Management Information of the University of South Africa. The model identifies the fundamental entities of the university as environment, finance, physical facilities, assets, personnel, and students. The model proposes a computerized decision support system which analyzes the mathematical relationships between different components of the system. The support system's data flow plan is presented as a plan that can be constructed independently within each entity, that generates output that can be used by another model as input, and that enables the measurement of variables in one submodel compared to another. The model emphasizes integrated scenario construction, in which a single run can potentially produce outputs of enrollment projections and projections of the needs for personnel, physical facilities, and finances. The paper describes the hardware and software requirements; the structure of files in the system; and the application of the model to enrollment, personnel planning, physical planning, long-term physical planning, and subsidy planning. A final section treats the establishment and use of efficiency measurements. Included are 15 figures and 6 references. (JB)

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AN INTEGRATED DECISION SUPPORT SYSTEM FOR PLANNING AND MEASURING INSTITUTIONAL EFFICIENCY

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for Management Research, Policy Analysis, and Planning

This paper was presented at the Thirty-Second Annual Forum of the Association for Institutional Research held at the Atlanta Hilton & Towers, Atlanta, Georgia, May 10-13, 1992. This paper was reviewed by the AIR Forum Publications Committee and was judged to be of high quality and of interest to others concerned with the research of higher education. It has therefore been selected to be included in the ERIC Collection of Forum Papers.

Jean Endo
Chair and Editor
Forum Publications
Editorial Advisory Committee

AN INTEGRATED DECISION SUPPORT SYSTEM FOR PLANNING AND MEASURING INSTITUTIONAL EFFICIENCY

1. INTRODUCTION

Efficiency, effectiveness and quality assurance are essential elements of university management, not only on the macrolevel but also on the departmental level. This is further necessitated by a rapidly changing demography, technology, economy and politics. Most measurements and assesments, however, occur post facto; that is, after the fact. The water has already gone under the bridge. There is a need to ensure efficiency and effectiveness on a **pro-active** basis - that is before the fact. The best way to ensure this is through effective decision making.

Every policy, every procedure, every result, in fact the very existence of a university is the result of a decision somewhere in the organization. Efficiency and effectiveness of operations therefore depends on the quality of decision making. The quality of decision making depends on the quality of management information.

The term "management" in a university often provokes resistance from academics because it is considered the antithesis of the concept of a community of scholars. This concept holds that no one person, or group of persons, should manage anyone in this cooperative endeavor. According to Hamblen (1971, p. 17), this resistance can be softened if the role of management in a university is understood to be that of creating and maintaining a proper environment for learning. This environment is the infrastructure of resources of the university.

A university is a very complex system and there are many variables in a university sytems that play a role in the decision making process. It is therefore necessary for the decision maker to have a good understanding of all variables in the university.

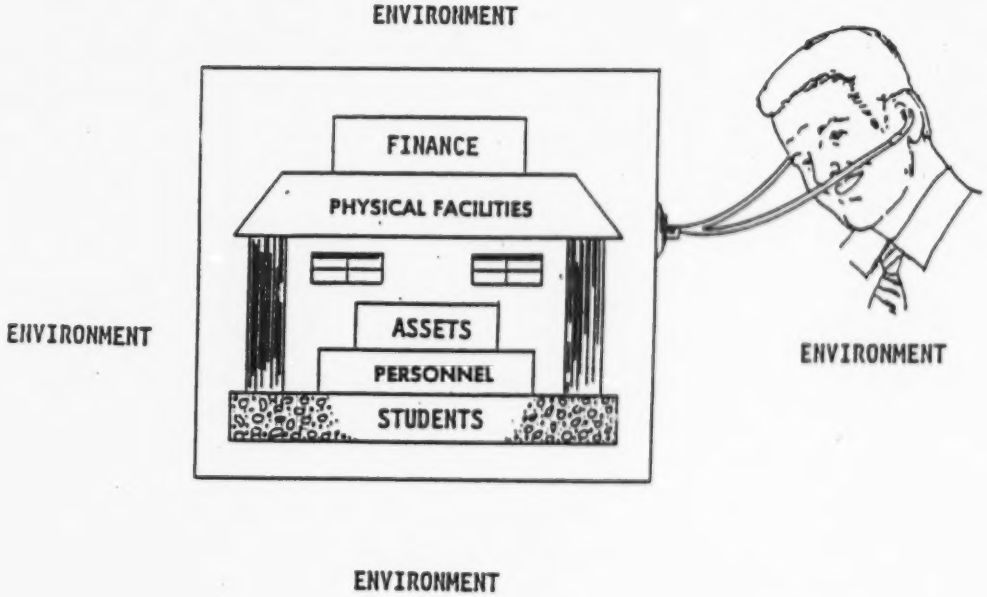
We will be looking at an integrated decision support system which provides management information for decision making in the planning of the resources of a university.

2. THE FUNDAMENTAL ENTITIES OF A UNIVERSITY

In order to build an integrated decision support system for a university it is necessary to identify the fundamental entities of a university.

There is a great diversity amongst universities. Every university has its own composition, traditions, history and local circumstances. There are even different university systems, such as the British system, the European system, the American system and the university systems of the East. In spite of the diversity there are a few basic entities which are common to all universities. These can be summarised as in Figure 1.

FIGURE 1



The entities of personnel, assets, physical facilities and finance form the resources which are needed to provide a service to students. Students, on the other hand, place a

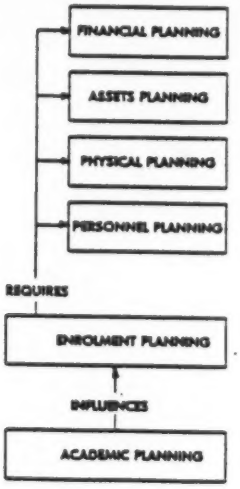
load on the resources of the university. This load is not only dependent on the number of students enrolled but rather on the number of subjects enrolled for. Each of these entities have distinct variables with certain attributes which are defined in terms of code structures.

Although every entity is a specialised field they are essentially interdependent. Any change in one entity has a ripple effect on all the other entities. Planning within the various entities should therefore not take place in isolation but should be fully integrated.

The planning framework of a university can therefore be summarised as shown in Figure 2.

FIGURE 2

FRAMEWORK FOR PLANNING



Academic planning form the basis of planning in a university. The academic offerings determine student enrolments which again determine the resources needed to provide an academic and administrative service to students.

3. DECISION SUPPORT SYSTEMS

Effective decision making within the planning context can be enhanced through a computerised Decision Support System (DSS).

In a DSS the mathematical relationships between different components of the system are identified and built into the system. This enables the decision maker to ask "what if" questions and obtain various scenario's. A model can therefore be described as a mathematical approximation of reality.

The basic requirements for an effective model are:

(1) A model must ease the decision making task of the decision maker;

(2) A model must contain all the elements of the decision problem;

(3) The mathematical relationships between components must be clearly defined and tested against reality;

(4) A model must be simple and easily understandable for non technical persons;

(5) A model must be stable, yet easily adaptable to cater for changing circumstances;

(6) A model must have an accurate and comprehensive historical data base on which to base the effect of decisions;

(7) A model must be executable in terms of data requirements and functioning;

(8) A model must be user friendly.

4. UNIPLAN

4.1 The general model

The Bureau for Management Information of the University of South Africa has developed an integrated model based on the framework for planning described in 2 and the requirements for a model described in 3. The model is known as UNIPLAN, which is an abbreviation of Uni<u>versity Plan</u>ning.

UNIPLAN consists of five submodels, namely:

(1) Student enrolment planning for the projection of future student enrolments.

(2) Personnel planning for the calculation of person power needs.

(3) Physical planning for determining the needs for physical facilities.

(4) Financial planning for determining expected state subsidies.

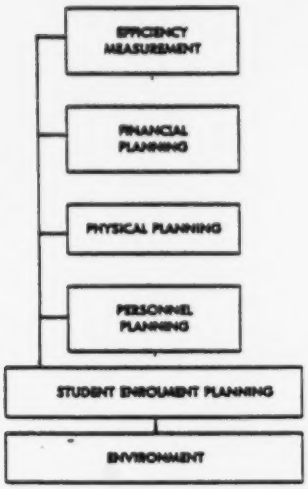
(5) Measuring efficiency criteria whereby the ratios between variables are measured and compared with norms to determine efficiency.

The data flow of UNIPLAN is shown in Figure 3.

FIGURE 3

UNIVERSITY PLANNING MODEL

(UNIPLAN)



There is no model for assets planning because asset expansion is usually not based on formulas but on substantiated individual needs.

UNIPLAN is designed so that:

(1) Scenario's can be constructed independently within each entity.

(2) The output of a submodel can be used by another model as input. This makes it possible to determine the ripple effect of a change in one entity on the other entities and ensures integrated planning.

(3) Any variable in any submodel can be measured against any variable in any other model for efficiency measurement.

The emphasis in UNIPLAN is on integrated scenario construction. A single run on the computer produces outputs

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of enrolment projections, and projections of the needs for personnel, physical facilities and finances.

4.2 **Software and hardware**

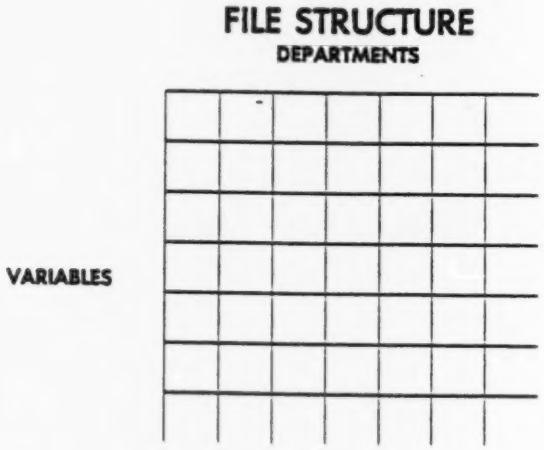
UNIPLAN was developed with FCS (Financial Control System), a modeling package produced by Thorn EMI Computer Software in Britian. It provides full programming capabilities using English like modeling instructions. It has matrix manipulation functions and has the capability of "what if" questions and sensitivity analysis.

UNIPLAN runs on a network of PC's. The various submodels are decentralised on the PC's in the offices of persons in the Bureau for Management Information specialising in student, personnel, financial and physical facilities planning. The network is run via a central file server which also serves to transfer files between the various models.

4.3 **File structure**

The files in all the submodels have the same basic structure as shown in FIGURE 4.

FIGURE 4

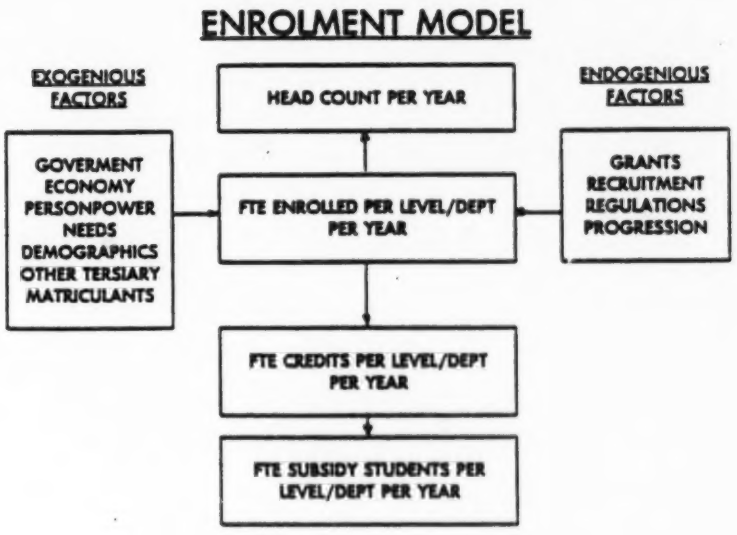


This structure makes it easier to add new variables and makes the models much more modular and easier to adapt to changing circumstances. It also ensures a uniform structure for intermodel comparisons.

4.4 Enrolment planning

This model is schematically shown in Figure 5.

FIGURE 5



An aggregated historical data base of 6 years was created from the student database on the mainframe and downloaded into the Enrolment Model. This data is then used to determine the ratios of first time entering students to matriculants and the ratios of other students to the population. These ratios are projected to the year 2010 and the projected ratios are then applied to official projections of matriculants and population in order to determine the number of expected enrolments in the future.

Apart from these basic projections various exogeneous and endogeneous factors which can have an effect on future enrolments were empirically investigated to determine the extent of their effect. These factors are:

Exogeneous	Endogeneous
Legislation	Grants
Economy	Recruiting
Person power needs	Regulations
Other tertiary institutions	Progression rates.

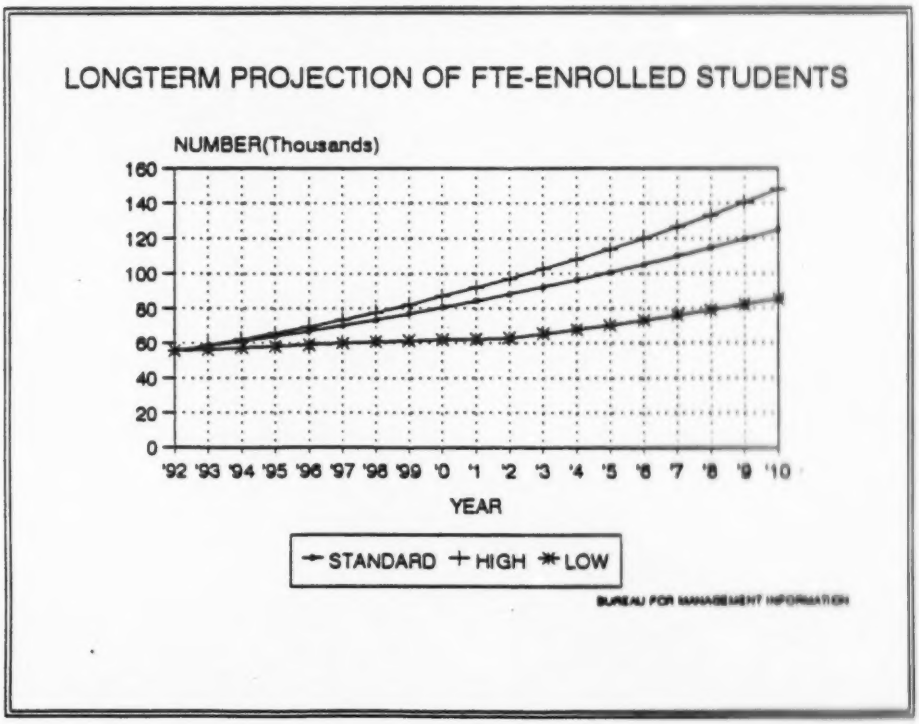
The effects of these factors are expressed as an expected percentage increase or decrease in enrolments e.g. a new regulation pertaining to entrance requirements is expected to result in a decrease of 5% in enrollment in a specific year. The total effect of all factors is determined on a multiplicative basis and applied to the basic projections.

The effects of each of these factors were empirically investigated by a team of experts in each field to determine their impact on future enrolments. A high and a low scenario were constructed. The total effect of the exogeneous factors indicated that an additional 1% per year in the growth rate can be expected, which will mean an average annual growth rate of 9.13% per year. For a university with over 110 000 students and, considering the stringent financial circumtances, an annual growth rate of this size can present serious problems in obtaining adequate resources.

A low scenario was therefore also constructed in which the effect of instituting certain new academic entrance requirements was calculated. This resulted in an expected average annual growth rate of 2.9% per year.

The result of the enrolment projections for UNISA is shown in FIGURE 6.

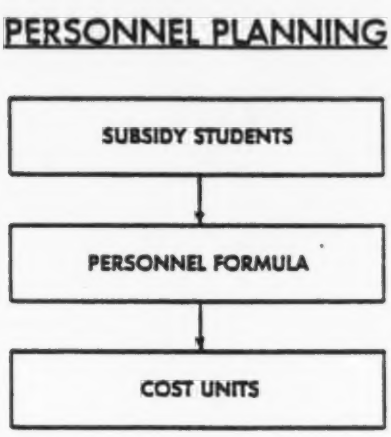
FIGURE 6



4.5 PERSONNEL PLANNING

The model is schematically illustrated in FIGURE 7.

FIGURE 7



Unisa has a personnel formula in which academic personnel positions are expressed in term of cost units. The total salary packet of a senior lecturer is taken as 1 cost unit. The cost unit of all other ranks are calculated relative to that of a senior lecturer and are as follows:

Professor	1.35
Associate professor	1.20
Senior Lecturer	1.00
Lecturer	0.90
Junior Lecturer	0.60

The total number of cost units available for allocation is distributed amongst departments with the following formula:

Cost units = $a * s^{0.6781}$

where a = a norming factor

s = subsidy students

= $(I + P)/3 * W$

where I = enrolled FTE

P = FTE Credits

W = Weighting factor

= 1 for undergraduate

2 for honors

3 for masters degrees

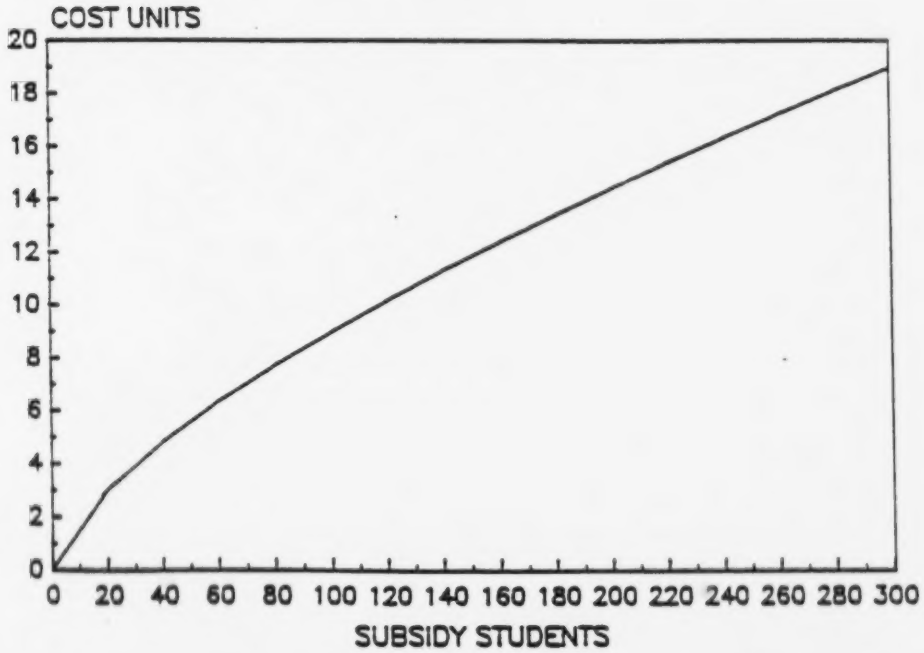
4 for doctoral degrees

The norming factor is calculated to scale the sum of the number of cost units generated down to that number which is available for allocation.

In a distance teaching university it is possible to obtain economies of scale in larger departments. The exponent of 0.6781 is derived from an economy of scale factor of 20%, which means a saving of 20% in faculty positions with a doubling in student numbers. The effect of this formula is graphically illustrated in FIGURE 8.

FIGURE 8

THE EFFECT OF ECONOMY OF SCALE
IN THE ACADEMIC PERSONNEL FORMULA



For every academic department a number of cost units are generated. Every department then has the autonomy to determine its own post structure as long as the "budget" of cost units available for that department is not exceeded. This eliminates personal politics to a large extent. The total salary commitment of the university is determined by applying the relevant monetary value to a cost unit.

The above formula has been incorporated in the personnel planning model of UNIPLAN in two ways, namely:

(1) To determine available cost units for individual departments in a specific year and to determine the effect of possible changes in departmental and course structure on cost units;

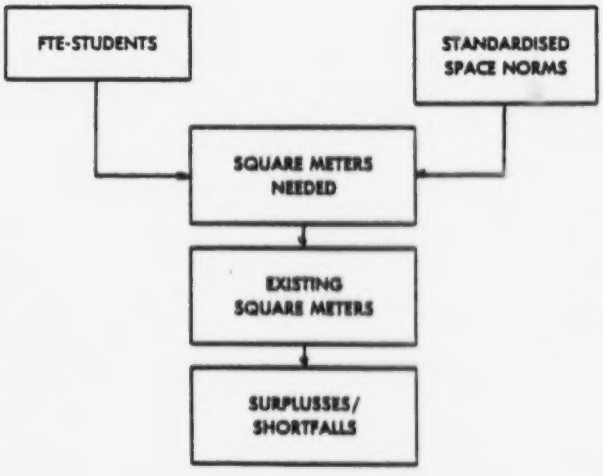
(2) To determine overall available cost units on the long term.

4.6 Physical planning model

The model is schematically shown in FIGURE 9.

FIGURE 9

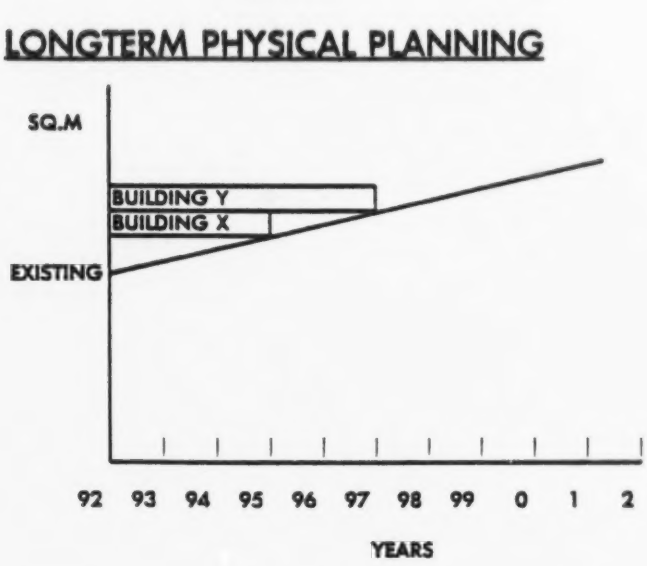
PHYSICAL PLANNING MODEL



The Department of National Education of South Africa has instituted a set of standardised space norms for universities, specifying the number of square meters of space needed per FTE student for various space categories. By incorporating these norms in the model and using the projected FTE enrolments generated by the Enrolment Model, the space needs of the university can be projected.

This then forms the basis of long term physical facilities planning. The erection of new buildings can then be scheduled to synchronise the availability of space with increasing student and personnel numbers, as shown in FIGURE 10.

FIGURE 10

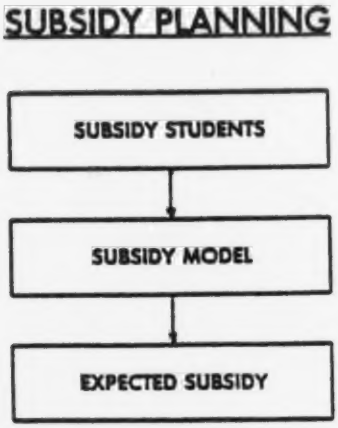


From these basic parameters the architects can then design the future buildings on the campus to produce a long term physical plan for the University.

4.7 Financial planning

The financial model is schematically shown in FIGURE 11.

FIGURE 11



All universities in South Africa are state universities and receive a state subsidy income for current expenses based on a standard formula. It caters for the following categories of expenditures:

(1) Salaries
(2) Supplies, services etc.
(3) Buildings and land improvements
(4) Equipment
(5) Book volumes
(6) Periodical volumes

The formulas used in this model are too comprehensive to explain in detail in this lecture but can be summarised with the following concept:

Subsidy income = S * N * C

where S = subsidy students
N = a constant equivalent to the number of cost units per subsidy student;
C = The Rand value of a cost unit and which can be adjusted form year to year to cater for inflation.

The model is able to calculate the longterm expected subsidy income based on expected enrolments. Provision is also made in the model for possible cuts in the subsidy and to develop optimistic and pessimistic scenarios.

The output of the model is shown in FIGURE 12.

FIGURE 12
EXPECTED SUBSIDY INCOME

ITEM	FORMULA	STATE CONTRIBUTION	SUBSIDY CUT
SALARIES	57 333 715	45 169 768	36 135 799
SUPPLIES AND SERVICES	16 419 858	12 936 208	10 348 966
EQUIPMENT	3 980 134	3 135 706	2 508 564
BOOKS	1 284 100	1 011 664	809 331
JOURNALS	2 740 800	2 159 309	1 727 448
	81 758 607	64 412 635	51 530 108

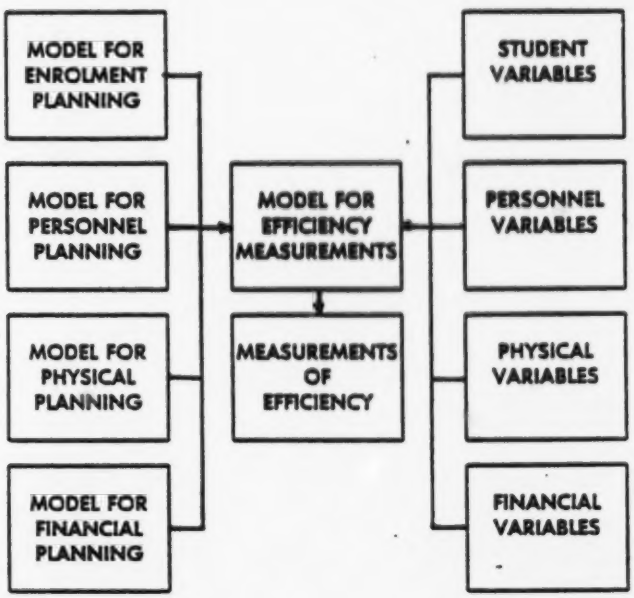
The result of this model, together with estimates of student and other income, is used to calculated a framework of income within which budgeting can take place.

4.8 Efficiency measurement

This model is shown schematically in FIGURE 13.

FIGURE 13

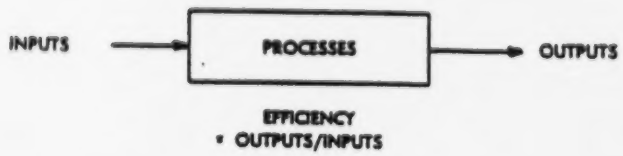
EFFICIENCY MEASUREMENT MODEL



According to Davis and Olsen (1985, p 287) efficiency can be depicted as in Figure 14.

FIGURE 14

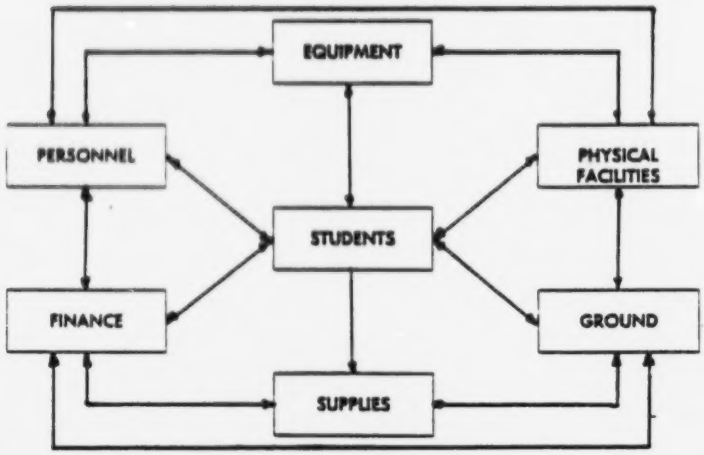
EFFICIENCY MEASUREMENT



Whereas effectiveness is a measurement of "how good" the output is, efficiency is a measurement of the resources needed to produce the output. The quality of resources is very important but the measurement thereof is very subjective and not easy to incorporate in a model. The quantitative measurement of efficiency entails measuring the ratios of the values of different variables relative to each other as shown in FIGURE 15. These measurements are generally known as performance indicators.

FIGURE 15

RATIOS



From historical measurements it is possible to construct norms or performance indicators for the efficient use of resources. These indicators can then become accepted goals and objectives of the university.

It must be stated categorically that these norms must be treated with great circumspection because every department is distinct. There are substantial differences between the department of Physics, with its laboratories, and the department of English, for example.

Efficiency measurements thus provide the following possibilities:

(1) Variance analyses

Variance from accepted norms can be clearly identified. Problem areas in the university can thus be identified and further investigated to determine the reasons for the variance.

(2) Trends

The measurement of efficiency criteria makes it possible to determine trends over time in the utilization of the infrastructure of the university. These trends can show a positive movement in the direction of stated goals and objectives or deteriorating circumstances which holds potential dangers for the university in the long term. The early identification of these dangers makes it possible to act pro-actively and institute procedures to move in the direction of the goals.

There are many examples of performance indicators as can be seen in the literature. The advantage of UNIPLAN is that it provides a logically structured and integrated system for incorporating a great variety of university variables and the capability of calculating any performance indicator on a continious basis. The longterm effect of different scenarios on performance indicators e.g. student/staff ratio can be detected in UNIPLAN.

Examples of the many performance indicators that can be measured with UNIPLAN are the following:

Student/Staff ratios
Expenditure per FTE student
Subsidy income per FTE-students
Research income per FTE faculty
Number of research articles per FTE faculty
Number of PC's per FTE faculty
Square meters of class rooms per FTE student

6. CONCLUSIONS

UNIPLAN is a decision support system which ensures integration of the various planning functions. It meets the basic requirements of a model and is very adaptable to changing circumstances. The efficiency measurement model is a powerful tool for monitoring the efficient use of university resources.

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